CLINICAL ARTICLE

Percutaneous Full Endoscopic Lumbar Discectomy for Symptomatic Adjacent Segment Disease after Lumbar Fusion in Elderly Patients

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Purpose: Treatment of adjacent segment disease (ASD) is still controversial. The aim of this study was to evaluate the short-term efficacy and safety and to analyze the technical advantages, surgical approach, and indications of percutaneous full endoscopic lumbar discectomy (PELD) in the treatment of ASD after lumbar fusion in elderly patients.

Methods: A retrospective of 32 patients with symptomatic ASD were accepted for PELD from October 2017 to January 2020. All patients used the transforaminal approach and recorded the operation time and intraoperative conditions. Preoperative, 3, 12, 24 months of postoperative and at the last follow-up, the pain of back and leg of visual analog scale (VAS), Oswestry dysfunction index (ODI), and Japanese Orthopaedic Association Assessment Treatment Score (JOA) were performed, and the paired student's t test was used to the compare the continuous variables preoperatively and postoperatively. The clinical efficacy was evaluated according to MacNab standards. The lumbar MRI was performed to evaluate the decompression of the nerve roots, and the lumbar lateral and dynamic X-rays were performed to evaluate the stability of the surgical segment.

Results: A total of 32 patients were included in the study, including 17 males and 15 females. The follow-up time ranged from 24 to 50 months, with an average of (33.2 ± 8.1) months and an average operation time of (62.7 ± 28.1) minutes. Compared to preoperatively, the VAS score of the back and leg pain ($p < 0.05$), ODI ($p < 0.05$), and JOA ($p < 0.05$) postoperatively were significantly improved. At the last follow-up, according to the modified MacNab standard assessment, 24 cases were excellent, five cases were good, and three cases were fair, the excellent and good rate was 90.65%. As for complications, one case had a small rupture of the dural sac during the operation, which was found but not repaired during the operation, and one case recurred after the operation. At the last follow-up, there were three cases of intervertebral instability.

Conclusion: PELD showed satisfactory short-term efficacy and safety in the management of ASD after lumbar fusion in elderly patients. Therefore, PELD might be an alternative choice for elderly patients with symptomatic ASD after lumbar fusion, but surgical indications must be strictly controlled.

Key words: Adjacent Segment Disease; Elderly Patients; Lumbar Fusion; Minimally Invasive; Percutaneous Full Endoscopic Lumbar Discectomy

Introduction

Lumbar degenerative diseases are common in the elderly. When conservative treatment fails, lumbar fusion is a traditional surgical treatment method which has been widely used to treat degenerative lumbar diseases. At the same time, adjacent segment disease (ASD) after lumbar fusion is a common postoperative complication, which can cause low back pain, lower limb radiation pain, intermittent claudication and other clinical manifestations.

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Adjacent segment degeneration is more common in imaging after spinal fusion, and the incidence rate is about 5.9%[1,2] every year. The incidence rate of symptomatic adjacent vertebral diseases is 5.2%–18.5%, and the reoperation rate is 1.8% per year. Lumbar disc herniation (LDH) is the most common,[3,4] including low back pain, radiation pain, intermittent claudication, etc. According to statistics, about 1/3–1/4 of patients with adjacent segment degeneration will have corresponding clinical manifestations and progress to adjacent segment disease.[5]

Some studies have reported that for patients with ASD, adjacent segment revision, extension, fixation, and fusion surgery is a more common surgical method,[6,7] which can reconstruct the stability of the spine, but requires the original incision and re-decompression and fixation. The original structure of the surgical approach was destroyed by the previous operation, and local scar formation after the operation also brought difficulties to the second operation.[8] In addition, lengthening the incision will bring more trauma to the patient, and lengthening the fixation will further accelerate the degeneration and stenosis of the adjacent segments and fall into a vicious circle. The second lumbar decompression and fixed fusion surgery may bring about new adjacent segment degeneration. As the number of fused segments increases, the risk of adjacent segment degeneration gradually increases.[9] Some new minimally invasive and non-fusion surgeries, such as minimally invasive transforaminal lumbar fusion (MIS-TLIF), dynamic rigid fixation, interspinous process expansion device, total disc replacement (TDR) can reduce the risk of postoperative ASD to a certain extent,[10–14] but the above methods lack the support of long-term follow-up evidence.

In recent years, the technology of percutaneous full endoscopic lumbar discectomy (PELD) has developed rapidly, and with the help of the endoscopic system for positioning, foraminoplasty, and nerve root decompression, the difficulty of the operation is reduced. It is possible to decompress more complicated ASD. The foraminoplasty is performed by removing part of the superior articular process, so that the endoscopic instrument enters the spinal canal from the enlarged intervertebral foramen, allowing the surgeon to clearly observe the foramen and the internal structure of the spinal canal, facilitating the removal of the lumbar disc and the resection of the hypertrophic ligamentum flavum. Thus, the effect and safety of surgical decompression have been significantly improved.[15]

There are still few reports on the effect of PELD in the treatment of symptomatic ASD, the selection of surgical methods is still based on the experience of the surgeon, and there is a lack of effective reference standards. Therefore, the purpose of this study is to explore the short-term efficacy and safety of PELD in the treatment of 32 elderly patients with symptomatic ASD, and discuss the advantages of PELD in the treatment of symptomatic ASD.

Materials and Methods

Clinical Data

This study was approved by the Ethics Committee of West China Hospital at Sichuan University (Science Research No. 63 in 2021).

The inclusion criteria: (1) patients over 60 years of age who have symptomatic ASD and have unilateral lower limb muscle strength and sensory changes, and have unilateral lower limb intermittent claudication. The symptoms cannot be relieved after 6 months of strict conservative treatment or repeat frequently; (2) there was no obvious instability in the adjacent segments after lumbar fusion; (3) lower extremity symptoms caused by neurology and lower extremity blood vessels are excluded. The exclusion criteria: (1) abnormalities such as instability and spondylolisthesis of adjacent segments have occurred; (2) people with mental illnesses that affect accurate assessment; (3) there is upper motor neuron disease. From October 2017 to January 2020, a total of 32 elderly patients with symptomatic ASD were enrolled.

Operative Technique

Anesthesia and Position

The operation was performed under local anesthesia and the patient was placed in a prone position.

Approach and Endoscopic Operatioin

All patients used the transforaminal approach, the distances beside the midline of the spinous processes of the L2/3, L3/4, L4/5, and L5/S1 gaps were 8–10 cm, 8–10 cm, 10–12, 8–12 cm, respectively. The 1–2 cm position on the head side of the horizontal line of the target gap was used as the positioning point to determine the puncture path. The 18 G needle was used for puncture, and the C-arm fluoroscopy confirms that the puncture needle reaches the target area. Generally, the base of the superior articular process was the puncture target. The skin incision was about 7–10 mm in length, and the expansion sleeve, working sleeve, and 8.5 mm trephine were inserted in sequence. The ventral bone of the superior articular process was removed for the foraminoplasty. If necessary, the foraminoplasty may be performed several times under visual inspection to deal with the herniated disc and the lateral recess.

Decompression Standard

The standard of surgical decompression was that the inner edge of the nerve root was visible, the nerve root tension was restored, and there was no obvious compression. After confirming that there was no abnormality, the working sleeve and instruments were removed. The incision was sutured intracutaneously with one stitch, and a small sterile dressing was applied to cover the bandage.

Postoperative Management

On the first day after operation, the patient can move down to the ground after wearing a waistline. Avoid strenuous activity within 6 weeks after surgery.

Clinical Effect Evaluation

The perioperative data were recorded, and the pain of back and leg of visual analog scale (VAS), Oswestry dysfunction index (ODI), and Japanese Orthopaedic Association Assessment Treatment Score (JOA) were recorded, and the clinical efficacy was evaluated according to MacNab standards. The lumbar MRI was performed to evaluate the decompression of the nerve roots, and the lumbar lateral and dynamic X-rays were performed to evaluate the stability of the surgical segment.

Statistical Analysis

The data was statistically analyzed using SPSS 23.0 (SPSS Corporation, USA) software, and the paired student's t test was used to the compare the continuous variables preoperatively and postoperatively, including VAS, ODI, and JOA score. $p < 0.05$ indicates that the difference is statistically significant.

Result

The Basic Information of the Patients

The basic information of the patients is shown in Table 1. A total of 32 patients with symptomatic ASD were included, including 17 males and 15 females, with an average age of (71.0 ± 10.5) years and an average body mass index of (25.4 ± 4.9) kg/m^2. The average operation interval between two operations was (73.6 ± 42.4) months, the average duration of symptoms was (9.1 ± 13.8) months, and the follow-up time ranged from 24 to 50 months, with an average of (33.2 ± 8.1) months. The lesions were located on the cephalic side of the fusion segment in 25 cases, five cases on the caudal side, and two cases on the cephalic and caudal side at the same time three cases with L2/L3 lesions, 17 cases with L3/L4 lesions, eight cases with L4/L5 lesions, and six cases with L5/S1 lesions. There were a total of 20 cases with one-segment fusion, 11 cases with two-segment fusion, and one case with three-segment fusion.

Table 1 The basic information of the patients

Variables	
Number of patients	32
Age (years)	71.0 ± 10.5
Gender (Male/Female)	17/15
Body mass index (kg/m^2)	25.4 ± 4.9
Average time between operations (months)	73.6 ± 42.4
Average duration of symptoms (months)	9.1 ± 13.8
Average follow-up time (months)	33.2 ± 8.1 (24–50)
Lesion location	
Cephalic side	25
Caudal side	5
Cephalic and caudal side	2
Distribution of lesion segment	
L2/3	3
L3/4	17
L4/5	8
L5/S1	6
Number of fused segments in the first operation	
1	20
2	11
3	1

The Hospitalization-Related Information of the Patients

The hospitalization-related information of the patients is shown in Table 2. The average operation time was (62.7 ± 28.1) minutes, the average intraoperative blood loss was (10.0 ± 8.3) ml, and the average hospital stay was (4.5 ± 2.3) days. One patient had nerve root irritation during the puncture process, who had L4/5 segment fusion and L3/4 had ASD, the irritation of the exit nerve root appeared during the foraminoplasty, and the irritation disappeared when the direction of the formation was changed to the caudal and dorsal side.

Complication and Typical Case

One case of a small rupture of the dural sac occurred during operation, which was found but not repaired during operation, and one case recurred after operation. None of the patients suffered from irreversible nerve injury, intervertebral space infection, and other related complications. Wearing a waistline and went out for activities under the guidance of medical care on the day after the operation. Two typical cases are shown in Figures 1, 2.

Comparison of the Patient Scores before and after Surgery

Comparison of the patient scores before and after surgery in Table 3. The low back pain score decreased from preoperative (4.7 ± 0.6) to (1.8 ± 0.4), the leg pain score decreased from preoperative (7.2 ± 0.7) to (2.2 ± 0.5), and the ODI decreased from preoperative (63.2 ± 7.8)% to (13.5 ± 5.4)%, JOA increased from preoperative (9.8 ± 4.3) to (27.8 ± 3.3), and the evaluation results at different follow-up time points were significantly different from preoperative evaluation results ($p < 0.05$). At the last follow-up, according to the modified MacNab criteria, the clinical results were rated as excellent in 24 cases, good in five cases, and fair in three cases, with an excellent and good rate of 90.63%.

Table 2 The hospitalization related information of the patients

Variables	
Average operation time (min)	62.7 ± 28.1
Average intraoperative blood loss (ml)	10.0 ± 8.3
Average length of hospital stay (days)	4.5 ± 2.3
MacNab standard evaluation	
Excellent	24
Good	5
Middle	3
Poor	0
Complication	
Rupture of the dural sac	1
Postoperative recurrence	3
Intervertebral instability	1

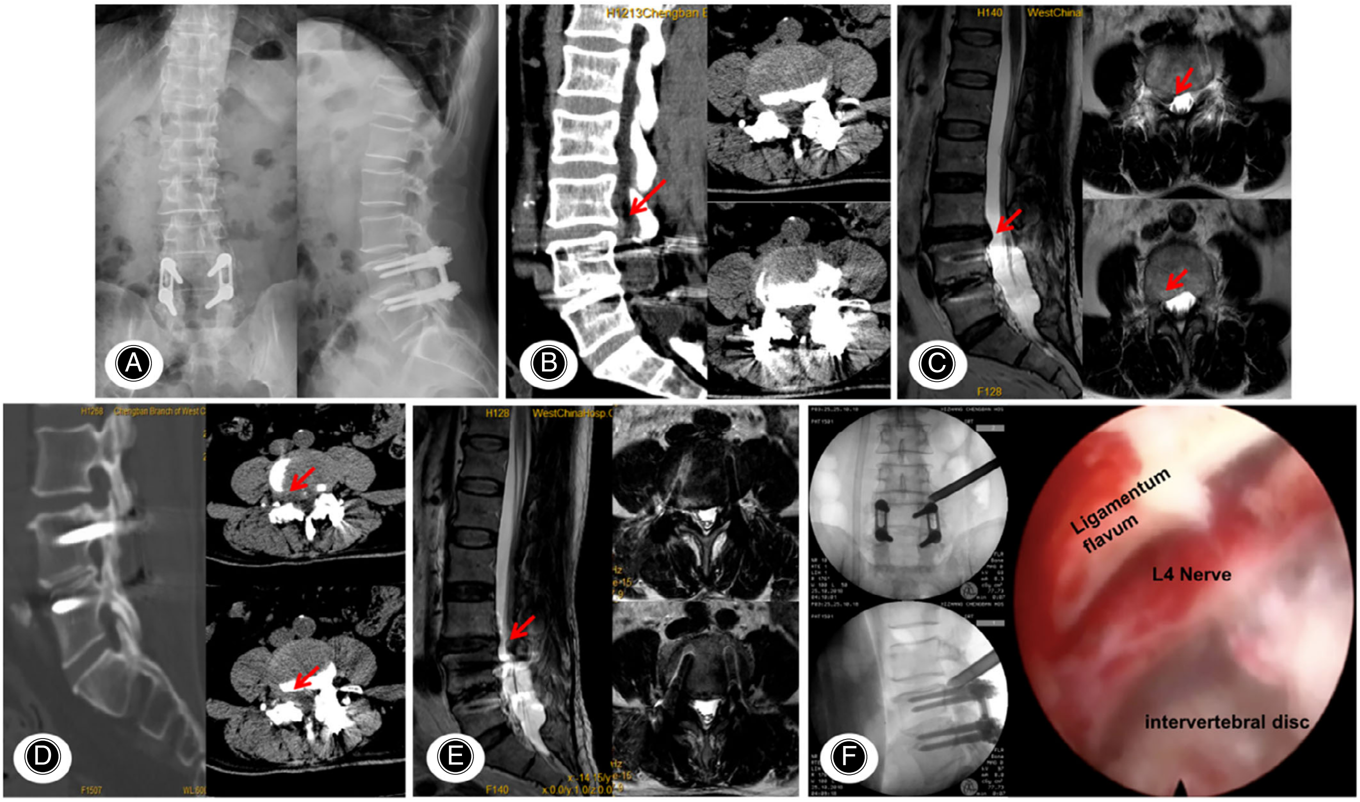

Figure 1 A 61-year-old man with symptomatic ASD who underwent PELD. (A) Preoperative anterior and lateral X-rays showed that the lumbar 4/5 had previously undergone PLIF surgery; (B, C) Preoperative CT and MRI showed herniation of the intervertebral disc in the right of adjacent lumbar 3/4 segment (red arrow); (D, E) Postoperative CT and MRI showed that the herniated intervertebral disc on the right side of the lumbar 3/4 had been removed (red arrow); (F) Intraoperative fluoroscopy showing the placement of the protective sleeve and L4 nerve root after decompression

Postoperative Imaging Results

Postoperative lumbar MRI showed that the compression of the ASD was relieved. At the last follow-up, the dynamic position X-ray of the lumbar showed three cases of intervertebral instability, of which two cases were L3/4 and one case was L4/5. All three patients had degenerations such as narrowing of the intervertebral space and smaller intervertebral foramen at the preoperative responsible segment. Among them, two cases had more articular process bones removed during the foraminoplasty. The fixation in the original fusion segment was not loosened or broken.

Discussion

Advantages of PELD in the Treatment of Symptomatic ASD

Compared with the traditional posterior extension fixation and fusion surgery, PELD has many advantages in the treatment of symptomatic ASD after lumbar fusion. In terms of anesthesia, the posterior lumbar revision, extension, fixation, and fusion surgery need to be performed under general anesthesia, while the PELD can be performed only under local anesthesia, the surgical risk is significantly lower for elderly people with more basic diseases. On the other hand, the surgeon can judge whether the nerve root is damaged through the real-time feedback of the patient's sensory and motor function changes during the operation, which ensures the curative effect of the operation and avoids the occurrence of serious neurological complications.[16] Therefore, performing surgery under local anesthesia is of great significance to ensure the efficacy of surgery and patient safety.

The PELD only needs to accommodate the working sleeve into the operating area, and the length of the incision is only 7–10 mm, which is significantly smaller than traditional minimally invasive surgery and open surgery. Reducing the surgical incision can reduce the amount of intraoperative blood loss, and the amount of intraoperative blood loss in endoscopic surgery is obviously less than in open surgery.[17] A small incision and less bleeding can reduce the trauma associated with the surgical approach, shorten the recovery time and hospital stay, and enable the patient to return to work as soon as possible.[18] In this study, the average operation time was (62.7 $\pm$ 28.1) minutes, the average blood loss was (10.0 $\pm$ 8.3) ml, and the average hospital stay was (4.5 $\pm$ 2.3) days, which are significantly shorter than traditional fixed

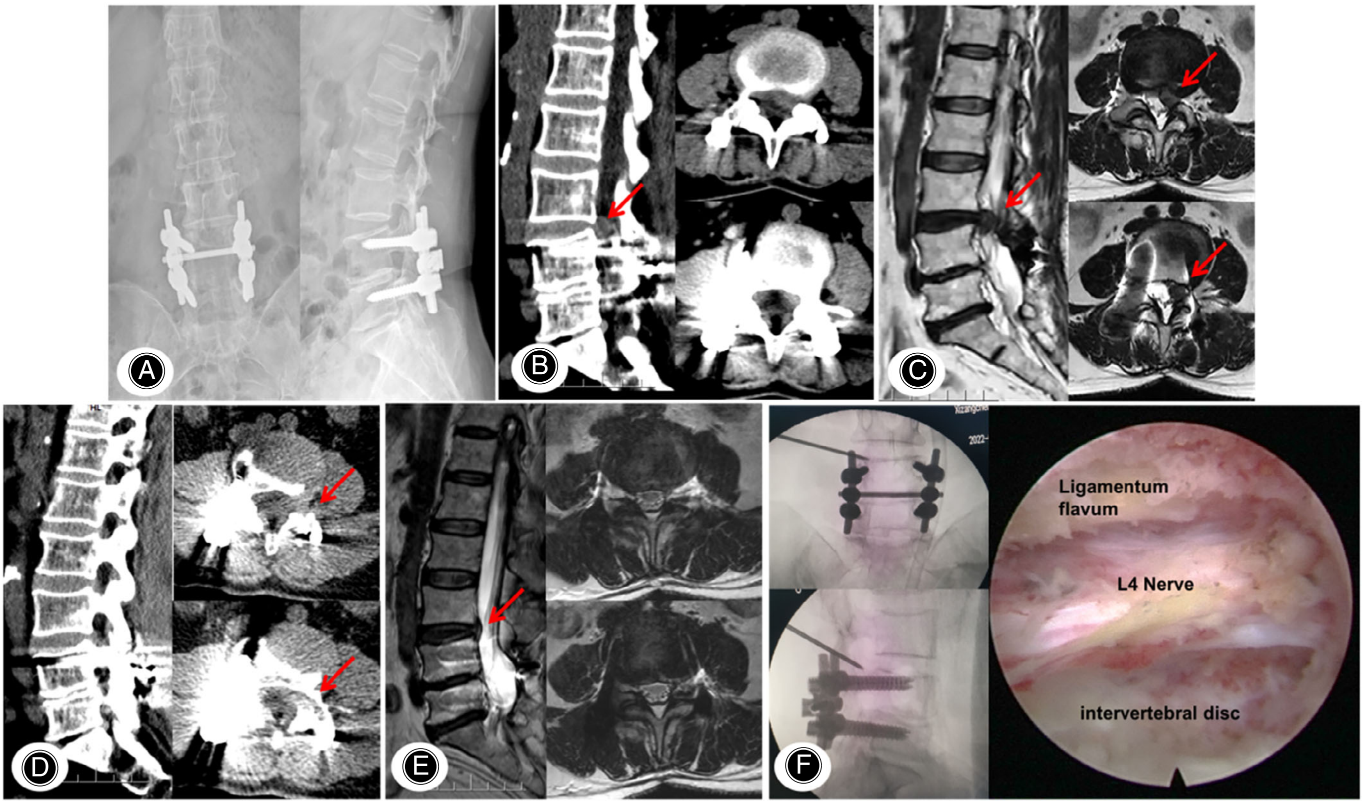

Figure 2 A 65-year-old woman with symptomatic ASD who underwent PELD. (A) Preoperative anterior and lateral X-rays showed that the lumbar 4/5 had previously undergone PLIF surgery; (B, C) Preoperative CT and MRI showed herniation of the intervertebral disc in the left of adjacent lumbar 3/4 segment (red arrow); (D, E) Postoperative CT and MRI showed that the herniated intervertebral disc on the left side of the lumbar 3/4 had been removed (red arrow); (F) Intraoperative fluoroscopy showing the placement of the guide needle and L4 nerve root after decompression

fusion surgery. The following three reasons are mainly considered. First, the surgical incision of the traditional lumbar posterior revision extension fixation and fusion surgery overlaps the surgical incision of the first lumbar fusion surgery. The first operation has destroyed the normal anatomical structure of the paravertebral muscles, spinal bones, and ligaments. Coupled with the formation of postoperative scar tissue, it creates difficulties for revision surgery. Second, the PELD requires small surgical incisions, small exposure area of the surgical area, simple intraoperative hemostasis, and the difficulty of establishing a surgical channel is lower than that of open spinal surgery. Third, the PELD only completes the adjacent segment nerve decompression without internal fixation and fusion, while the traditional posterior lumbar surgery will destroy the normal paravertebral muscle tissue, spinal ligament, and bony structure, and the stability of the spine is decreased.[19] Thus, intraoperative extension, fixation, and fusion are required, and the complexity of the operation is significantly higher than that of endoscopic surgery.

Table 3 Comparison of patient scores before and after surgery ($\bar{x} \pm s$)

Variables	Pre-	3-months post	12-months post	24-months post	Last follow-up
VAS for back pain	4.7 ± 0.6	2.1 ± 0.5*	1.9 ± 0.4*	1.8 ± 0.5*	1.8 ± 0.4*
VAS for leg pain	7.2 ± 0.7	2.8 ± 0.6*	2.3 ± 0.5*	2.2 ± 0.6*	2.2 ± 0.5*
ODI (%)	63.2 ± 7.8	13.9 ± 5.5*	13.6 ± 5.4*	13.5 ± 5.2*	13.5 ± 5.4*
JOA score	9.8 ± 4.3	27.8 ± 4.8*	27.5 ± 3.7*	27.6 ± 3.5*	27.8 ± 3.3*

Abbreviations: JOA, Japanese Orthopaedic Association Assessment Treatment Score; ODI, Oswestry dysfunction index; Pre Preoperative, Post post-operative; VAS, visual analog scale.; * Statistically significant different from mean preoperative value ($p < 0.05$).

The PELD has less damage to the bony structure and ligament muscle tissue of the spine, avoiding extensive exposure of the posterior muscles and removal of lamina, facet joints, and ligamentum flavum and other posterior ligament complex structures. The biomechanical stability of the adjacent segments of the spine is preserved as much as possible, which speeds up postoperative recovery, reduces the postoperative pain syndrome of the patient's lower back, and also reduces the risk of secondary degeneration of adjacent segments of the lumbar spine.[20] At the same time, the technology has little interference to the dural sac and nerves in the spinal canal, and can reduce the incidence of spinal canal and nerve adhesions due to scar hyperplasia after surgery. There is no need to replace or extend the internal fixation, which avoids many complications such as nerve root and dural sac injury during the nail placement, and the loosening and rupture of the internal fixation after the operation.

Selection of Surgical Approach and Surgical Indications

The surgical approach of PELD can be divided into transforaminal approach and interlaminar approach. The transforaminal approach does not require a posterior incision, avoiding the influence of the initial operation to destroy the anatomical structure of the posterior approach. The operation only needs to complete the foraminoplasty, without massive destruction of the paravertebral muscles, ligaments, and bony structures, and can fully preserve the biomechanical stability of the spine. The interlaminar approach is difficult to separate the scar tissue formed during the initial open surgery under the endoscope, which may easily lead to complications such as dural sac tear, nerve damage, and residual nucleus pulposus. Some patients have internal fixation nails and a horizontal connection, which can affect the placement of the working channel of the interlaminar approach. All the patients in this study adopted the transforaminal approach, without the first surgical incision reaching the operating area, which can avoid the inconvenience caused by the original incision.The traditional concept believes that spinal fusion surgery should be performed to reconstruct the stability of the spine in patients with instability, but the clinical significance of spinal instability remains to be clarified.[21] At present, there is still controversy regarding the treatment of patients with unstable adjacent segments by PELD.[22] Telfeian et al.[23] pointed out that degeneration of adjacent segments has always existed, and the clinical effect of PELD in the treatment of symptomatic ASD after lumbar fusion is only temporary. It was reported that the failure rate of nine cases of percutaneous transforaminal endoscopic treatment of symptomatic ASD after lumbar fusion was 33% after 2 years operation, which may be related to the small number of patients included by the author and the presence of adjacent segmental instability in the included patients. The cohort study of the Ba Z. team reported the clinical efficacy of transforaminal lumbar endoscopic decompression surgery and lumbar fusion surgery for the treatment of ASD after single-segment lumbar fusion. The results showed the clinical efficacy of the two surgical methods have no significant difference, and endoscopic surgery has the advantages of less surgical trauma and shorter hospital stay.[20] In this study, ASD patients with stable adjacent segments underwent PELD with good results in terms of recovery of spinal cord function and improvement of low back and leg pain. Evaluation according to the modified MacNab standard showed that the excellent and good rate reached 90.63%. Therefore, it is necessary to strictly control the surgical indications in clinical diagnosis and treatment and take into account the patient's clinical and imaging manifestations. For patients with radicular radiating pain and intermittent claudication, the first choice is nerve decompression, while the patients with low back pain caused by segmental instability of the lumbar spine tend to undergo fixation and fusion surgery to reconstruct spinal stability.

Strengths and Limitations

This study systematically reviewed and analyzed the effect of PELD in the treatment of symptomatic ASD. But there are some limitations and shortcomings in the study. The first was that this study was a retrospective study and the sample size was small, so the results of prospective randomized controlled studies with large sample sizes in the future will be more convincing. The second is that the follow-up time of this study is relatively short, long-term observation should be carried out to clarify the effectiveness and safety of PELD. The third is that there is no control group in this study, which may be an important limitation.

Conclusions

For patients with unilateral lower extremity root symptoms or intermittent claudication symptoms and adjacent segments with stable imaging, the treatment of PELD shows satisfactory short-term efficacy and safety, and can be used as an alternative choice for elderly patients with symptomatic ASD after lumbar fusion.

Author Contributions

Pin Feng: Conceptualization, Methodology, Investigation, Software, Writing—original draft, Funding acquisition. Junlin Liu: Methodology, Data curation, Investigation, Writing—original draft. Qingquan Kong: Conceptualization, Methodology, Data curation, Validation, Writing—review & editing. Bin Zhang: Conceptualization, Methodology, and Writing—original draft. Yuan Hu: Methodology, Data curation, Investigation. Junsong Ma: Methodology, Data curation, Investigation.

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Conflicts of Interest Statement

The authors declare that they have no competing interests.

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